10/069942
JC13 Rec'd PCT/PTO 06 MAR 2002

3/prts

SENSOR FOR MEASURING CLEARANCE BY MULTIPLE DEPTH ABRASION

The invention relates to a device for measuring the clearance between the tips of the blades of a ring of blades and the interior wall of the casing (5) surrounding said ring of blades in a turbomachine.

In the development of turbomachines, knowledge of the blade tip clearances is a fundamental element in mastering the thermodynamics of the machine, so as to improve its performance.

Every effort is made to make this clearance as small as possible, while at the same time avoiding the risk of the blade tips rubbing against the interior wall of the casing.

However, given that it is extremely difficult to optimize this clearance through calculation, because of the many mechanical or thermal parameters involved, it becomes necessary to resort to measuring the clearance between the blade tips and the interior wall of the casing using sensors.

The clearance may be measured continuously in operation. In this case, use is made of sensors of the capacitive type, which give low-amplitude signals.

The clearance may also be measured spot wise during testing or maintenance. In this case, use is generally made of a probe made of an abrasive material which comprises a U-shaped electrical circuit, the base of which is a certain distance from the internal wall of the casing. When the base of the electrical circuit is eroded by abrasion, the electrical circuit opens,

the clearance is then smaller than the distance than corresponds to a calibrated depth of clearance. This sensor has the advantage that it is robust, but it gives just one result during the course of the test.

Now, it is often desirable to measure the occurrence of several sites of clearance during the same turbomachine test. To do this, use is made in practice of several sensors of the resistive type at the periphery of the ring of blades, each of which defines a calibrated depth of clearance.

Starting out from this prior art, the invention set itself the objective of providing a simple, reliable and inexpensive device that made it possible to measure several decreasing depths of clearance.

The invention achieves its objective in that the device proposed comprises a probe which can be mounted radially on the casing and at least one end of which is made of a material that can be abraded by the tips of the blades as they rotate, a printed circuit arranged in the mid-plane of said probe which contains the axis of rotation of the ring of blades, this printed circuit comprising a number of adjacent U-shaped electrical circuits the bases of which are arranged in a probe end likely to be abraded by the blade tips and lie at different depths from a reference level defining the interior wall of the casing, and means for recognizing the U-shaped electrical circuits which have been broken by abrasion and the electrical circuits which are intact.

Each base thus corresponds to a calibrated depth of clearance and the device makes it possible, in the course of the one same test, to observe any decrease in clearance, and the position of the blade tips between two calibrated depths. Implementation of the device entails accurately positioning a single sensor, whereas in the prior art, several sensors each having just one U-shaped electrical circuit, had to be positioned accurately.

To reduce the number of conducting tracks in the printed circuit, two adjacent electrical circuits have a common branch.

Advantageously, the depths of the bases increase by a predetermined step between the shortest lateral electrical circuit and the longest lateral electrical circuit.

To reduce the external wiring of the probe, the outer branch of the shortest lateral electrical circuit is connected to a first electrical terminal, and the other branches of the electrical circuits are connected to a second electrical terminal via a resistor of a set of resistors.

As a preference, the resistors of the set all have practically the same resistance. The terminals are connected to an electrical circuit external to the probe which comprises means for measuring the equivalent impedance of the resistors of the intact circuits. This impedance measurement makes it possible to determine the number of longest circuits broken and

thereby the position of the clearance remaining between two calibrated depths of clearance.

Other advantages and features of the invention will become apparent from reading the following description which is given by way of example and with reference to the appended drawings, in which:

- figure 1 is a schematic view of the device according to the invention, showing the probe mounted on the casing and the associated measurement means;
- figure 2 is a perspective view of the probe;
- figure 3 is a front view of the printed circuit; and
- figure 4 is a view on the mid-plane of the probe passing through the axis of rotation of the ring of blades and which shows the printed circuit partially abraded by the blade tips.

Figure 1 shows an impeller 1 of a turbomachine of axis X, which comprises, at its periphery, a ring of blades 2 the tips 3 of which are arranged a distance J or clearance away from the internal wall 4 of a casing 5 of axis X. Arranged in an orifice 6 of this casing 5 is a probe 7 connected by electrical conductors 8 to a device 9 for measuring the clearance J.

The probe 7, shown in perspective in figure 2, is in the form of a cylindrical body consisting of two half-cylinders 10a, 10b between which a printed circuit 12 is held by bonding or by pressure. The two half-cylinders 10a and 10b are made of a material that can be abraded by the tips 3 of the blades 2, such as

Teflon or graphite.

The printed circuit 12 is preferably flexible and possibly multilayer. The lower edge 13 of the printed circuit 12 is arranged in the end face of the probe 7 which is intended to be introduced into the casing 5.

The other end 14 of the printed circuit emerges from the upper face 15 of the probe 7 and in particular comprises the connections and the electrical terminals 16a, 16b for the connecting of the electrical conductors 8.

The printed circuit 12 comprises a number of adjacent U-shaped electrical circuits 20a to 20e consisting of parallel and vertical conducting branches 21a to 21f of different lengths increasing from left to right, as shown in figure 3, and bases 22a to 22e parallel to the edge 13 and offset vertically by a constant step p. Each base connects the lower end of a left-hand branch to the immediately adjacent branch to the right. Each intermediate branch 21b to 21e constitutes an electrical branch for two adjacent electrical circuits.

The outer branch 21a of the shortest electrical circuit 20a is connected to the electrical terminal 16a. The other branches 21b to 21f are connected to the terminal 16b each via a resistor R. As a preference, all the resistors R have the same resistance.

The reference 24 denotes a reference level parallel to the edge 13. Thus, the bases 22a to 22e of

the printed circuits 20a to 20e are arranged at respective depths za to ze with respect to the reference level 24.

Figure 4 shows the arrangement of the probe 7 in the orifice 6 of the casing 5. The base 22a of the electrical circuit 20a is arranged in the plane tangential to the interior wall 4 of the casing 5, by way of example. Thus, the bases 22b to 22e of the other electrical circuits 20b to 20e are spaced away from the interior wall 4 of the casing 5 by a distance respectively equal to p, 2p, 3p and 4p.

If the clearance J is between zd and ze as shown in figure 4, then the lower end of the probe 7, showed in dotted line in figure 4, is abraded by the end 3 of the blades 2 rotating about the axis X. The branch 22e has been eroded by abrasion. The circuit 20e is therefore broken, and no current can pass through the right-most resistor R of the set visible in figure 3.

If, during the turbomachine operating test, the clearance J decreases and falls between zc and zd, then the base 22d will in turn be eroded, and only three resistors R will have current passing through them during the test. The above process is repeated in each of the circuits in the order of their decreasing height as the clearance J is used up.

The resistors R may be produced either in the form of CMS resistors, or in the form of a thick film deposit. The presence of resistors R makes it possible

for the probe 7 to be connected to the device 9 for measuring the clearance J by two electrical conductors 8. This measurement device 9 essentially comprises a DC current source G, a voltmeter and ammeter, or more simply an ohmmeter.

The ratio between the voltage measurement V and the current measurement I makes it possible to determine the value of the impedance Z of the network of resistors R during the test and thereby to determine the number of electrical circuits which are intact and the number of electrical circuits which are broken. From this, the position of the tips 3 of the blades 2 with respect to the internal wall 4 of the casing 5 can easily be determined.